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XLV.—*On the Larval State and Metamorphosis of the Ophiuridæ and Echinidæ.* By Prof. J. MÜLLER*.

[With a Plate.]

I HAD occasion last year to describe some animal forms observed near Heligoland, among which was one peculiarly remarkable from its form and skeleton, to which I gave the name of *Pluteus paradoxus*. During the present year I have been able to extend my observations and to study the further development and metamorphosis of this remarkable animal, which have proved highly interesting. In fact, an *Ophiura* is developed from it; *Pluteus paradoxus* is consequently the larva of an *Ophiura*.

The first observations instituted on the development of an Echinoderm were those of M. Sars on *Echinaster sanguinolentus* (*Echinaster Sarsii*, Müll., Trosch.) and *Asteracanthion Mülleri*, Sars. This naturalist, to whom we are already indebted for the discovery of many important facts on the changes in form of the lower animals during their development, has also observed, that the young *Asteriæ* have no similarity to their later forms. The larva of *Echinaster*, when it escapes from the ovum, is of an oval form, without any external organs, and by means of innumerable cilia which cover the body swims about free in the water just as the Infusoria, or the *Medusæ*, *Coryne* and *Alcyone* in their young state do. In a few days organs grow out at that extremity of the body which, when they swim, is seen to be the anterior; these serve for attachment. They consist of four bulbous tubercles with a smaller one in the centre. By the aid of these organs the young one fixes itself firmly to the marsupial cavity of the mother. These tubercles disappear when the body of the animal is developed into the radiate form. M. Sars has not given any illustration of the internal structure of these young Echinodermata or larvæ, which is sufficiently explained by their being perfectly opaque.

The larvæ of the Echinodermata, which form the subject of the present notice, are so transparent, that they admitted of a microscopic analysis with a magnifying power of 250 diameters.

* Translated by Dr. Griffith from the Berichte der Berliner Akademie for Oct. 29, 1846.

Before *Pluteus paradoxus* exhibits any trace of a star-fish, it has the form figured in Pl. XI. fig. 5. It has no further resemblance to the larvæ described by M. Sars than in the appendages being developed in one direction and the animal being bilateral. In other respects the form is so peculiar and so very dissimilar, that it would never be suspected to be the larva of an Echinoderm, notwithstanding the previous observations of M. Sars. The appendages are numerous, viz. eight, and very long; they have no relation to tubercles and organs for attachment. The elegant skeleton of *Pluteus* has been already described. We must now add, that it is calcareous and dissolves in acids. The observations made during the present year, for the first time afford an explanation of its further internal structure and vital phenomena. The membrane which covers the columns of *Pluteus* extends over the body of the animal in arches from one column to the other. The intermediate substance descends deeper between two only of the columns which we shall call the posterior. The mouth is situated at the part at which, in my previous treatise, I noticed the occurrence of motion. Opposite the mouth at the anterior side, the skin of the body is extended between two of the columns like a marquise over a door. The oblique lower lip projects considerably forward at the mouth. The oral cavity leads upwards into an œsophagus, and this is connected by a contraction with the cæcal stomach, which fills the cavity of the body between those columns which are inclined towards each other. The stomach is often divided by a constriction into an ascending portion and a blind pouch recurved anteriorly. Two granular, glandular bodies, of the use of which I am ignorant, are situated on each side of the œsophagus and stomach. Before the metamorphosis commences, *Pluteus paradoxus* is rather less than half a line ($\frac{2}{3}$) in size. It occurs in great numbers during the months of August and September in the open sea near the surface, and swims by ciliary motion, usually with the appendages forwards; but sometimes it continues to revolve horizontally, whilst the azygous extremity and the long appendages retain an opposite and horizontal direction. Ciliary motion exists throughout the stomach, in the œsophagus and the cavity of the mouth; as also definitely distributed on the outside of the body. The mouth is surrounded by a tuft of cilia. The acute, azygous extremity of the animal is also surrounded by a circular tuft of cilia; the cilia then expand into the eight long appendages, so that in each there are two rows or tufted lines, upon which they are situated. Both rows or lines at the extremity of the appendage curve into one another; between two of the appendages or arms the line of cilia runs from one arm to the other on the arches we have mentioned; thus the entire animal is surrounded by a ciliated organ of

a linear form, which returns into itself, ascends and descends upon the arms in loops and passes from one arm to the other. In the situation of the mouth it passes beneath it. Ciliary motion alone effects the entire locomotion of the animal; all other spontaneous motion is confined to the closure of the mouth and œsophagus which takes place from time to time. The walls of the stomach are of a granular or cellular structure and appear green, the larva is otherwise perfectly transparent; its azygous apex and the extremities of all the arms are of an orange colour.

Distinct indications of the nervous system were also perceived. They consist of two small knots below the mouth, a right and left, which are connected by a filament, and send several filaments upwards towards the mouth and one downwards.

These *Ophiura* larvæ are not luminous.

The first indication, both internally and externally, of the transformation of the *Pluteus* into an Echinoderm, consists in the appearance of certain cæcal figures with double contours at the sides of the stomach and œsophagus. They are seen to form a row, first upon one and soon afterwards upon the other side of the stomach and œsophagus. The minute cæca are situated towards the exterior; their bases, which are connected together, are turned towards the stomach; each row appears like a thick membrane which has been thrown into cæcal folds. They soon completely surround the stomach like a wreath. At first they do not project beyond the surface of the *Pluteus*, but lie within its substance, their contours being lost in it, but by their growth they soon project beyond the surface of the *Pluteus*; subsequently others are developed which project beyond the crown formed by the former; these are neither more nor less than ten, each pair being situated near each other: this is the first appearance of the arms. The two belonging to each arm then fuse together, and the whole assumes the form of a disc, which is grown over by five short appendages. The former arms or columns of the *Pluteus* take no part in this formation. The *Pluteus* holds the same relations to the star-fish which is forming within it, as the embroidery frame does to the embroidery which is worked within it. Moreover the arms of the *Pluteus* have no relation to the arms of the Echinoderm. The latter is situated obliquely within the body of the *Pluteus*, so that one of the arms of the star-fish crosses the great axis of the *Pluteus*, and comes into view on the side of the azygous apex of the *Pluteus*. As soon as the cæca become arranged in the form of a crown or star, the deposition of lime occurs in the form of ramified figures in the new formation; during their further development these assume the form of a lattice-work, as is peculiar to the skeleton of Echinodermata. With the development of the minute cæca into a crown, distortion occurs at

that part of the *Pluteus* where the mouth was situated. This region now appears as if forcibly drawn obliquely upwards, and no further trace of the mouth of the larva is seen. But instead of the former lateral mouth of the *Pluteus*, there now appears a central mouth for the Echinoderm.

I have not been able to decide whether the mouth of the larva is transformed into the mouth of the *Ophiura*, or whether the latter is of perfectly independent origin and the former disappears. In the true *Echinidæ*, as in *Echinaster*, that spot in the newly-formed Echinoderm, at which the mouth is subsequently situated, is still perfectly closed, even when the first tentacles are formed. The mouth of the young *Ophiura* is at first round and totally dissimilar to the mouth of the larva; it gradually assumes a stellate form.

In the *Echinidæ*, where, as we shall hereafter see, four sides can be distinguished in the larva, the formation of the mouth of the *Echinus* is always independent of the mouth of the larva; for none of the poles of the young *Echinus* formed in the larva correspond to that side of the larva in which the mouth of the larva occurs.

In its present condition the newly-formed star-fish is always smaller than the remains of the *Pluteus*, but the more the star-fish grows, the more do the appendages and the azygous apex of the *Pluteus* appear as mere appendages of the star-fish. The azygous summit of the *Pluteus*, its two long lateral arms, and one of the two lower arms remain longest, but on the growth of the star-fish these at last also disappear. The stomach is the only structure in the new being which is completely received from the *Pluteus*.

The tentacles or feet of the young star-fish are also formed before the arms of the *Pluteus* disappear. At first there are only ten of them, which inclose the disc itself in a crown. Before the loss of any of the arms, two foramina are formed in the disc, from which the animal exerts the tentacles. At this period it still lives in the sea as before, but when it lies on the bottom of a vessel, it gropes about with the tentacles. The tentacles or little feet are covered with small knots, as in the *Ophiuræ*. In this state the animals move exactly as formerly by ciliary action, and we very frequently see the circular rotation in the plane of the longest or lateral arm of the *Pluteus*. So far we are unable to guess from the form of the animal, whether an *Asterias* or an *Ophiura* will form from the *Pluteus*; its remarkable difference from the larva of the *Asterias* of Sars indicates something distinct, and in fact the characters of the *Ophiura* soon show themselves. Shortly before the time when the last traces of the *Pluteus* disappear, we see that the arms of the star-fish are deposited by the disc and as it were articulated. But this

arm is now nothing more than the most external or terminal member of the future *Ophiura*. Just as the first tentacles are formed upon the disc itself, so is it with the first spines, ten of which are seen, each being traversed by a calcareous network, and situated near its tentacle. The animal has the power of spontaneously moving these spines, which also indicates the *Ophiura*. As soon as the young *Ophiura* has become developed, it is furnished with a disc which is traversed by lattice-work and incloses the stomach, and a mouth which is encircled by five triangular interradiial plates; outside these plates, on the abdominal side of the disc, there are two spines placed near each other, and sufficiently large to project beyond the margin of the disc. The two tentacles appear before the loss of the articulated arms. The arm-segment itself is narrow at the root, altogether it is longish and inflated. We meet with these young *Ophiuræ* in the upper parts of the open sea, although all traces of the organization of the *Pluteus* have disappeared. In size they are about equal to the breadth of the original *Pluteus*, and are about two-thirds of its length. The new segment of the arm is formed between the disc and the primitive segment, and is furnished with two spines articulated anteriorly to the sides, and two tentacles, one on each side. The young *Ophiura* with the two arm-segments is half a line in length. Subsequently a new segment is again formed between the disc and the arm and furnished with spines and tentacles. I have found these young *Ophiuræ* free in the sea up to that period at which their arms had four segments, and the number of spines on the segments had increased to two on each side of every segment. The entire animal has at this period a diameter of $\frac{3}{4}$ —1 line. The terminal segments of the arms or the primitive segments have not become altered either in form or size. The subsequent segments differ in form, being of a polygonal shape, as is peculiar to the segments of the arms of the *Ophiuræ*. The origin of all the new segments is from the ventral surface of the disc itself, between the interradiial plates of the disc, where the segments of the arms run towards the angle of the mouth. As soon as the new segment has grown beyond the disc, it forms the largest of the arm-segments. Thus far the genus of *Ophiuridæ* to which it belongs cannot be determined with certainty; probably it is an *Ophiolepis*, several species of which occur in the German Ocean.

Besides the above-described *Ophiura*, which in a very large number of specimens may be observed in all the transition stages, I found another *Pluteus*, *i. e.* the larva of another species of *Ophiura*; this however was only seen once. In form and in the skeleton it exactly resembled *Pluteus paradoxus*, but the arms of the larva diverged considerably more, and were much longer and

thinner. The uniform colour of the transparent animalcule was a very pale violet. Its size was double that of *Pluteus paradoxus*. There were no indications of its development into the star-fish.

I now come to another class of Echinodermatous larvæ, which I have traced as far as the period of their metamorphosis, so that there is no doubt in my mind regarding their Echinoid nature. I had no opportunity of observing the earliest development of the *Echinus* from the ovum, upon which point H. von Baer has instituted investigations by the artificial impregnation of the ova*. Von Baer compares the embryos of the *Echinus* to the earliest forms of the larvæ of the *Medusæ*, such as *Aurelia aurita*, as they occur in the sacs on the margins of the arms, except that they are much broader. During their further change, they appeared as if about to approach the *Beroë* in structure; on the fourth day they assumed very irregular forms which differed from each other; on the fifth day they were all dead. The motion of the larva when it has quitted the ovum is effected by cilia. Von Baer estimates the diameter of the young *Echinus* which he observed at $\frac{1}{30}$ th of a line.

The animals which formed the subject of my investigations, and which I consider as the larvæ of *Echini*, are much older, about half a line in diameter; in this condition they have no resemblance to the larvæ of the *Medusæ* and *Beroë*. I have observed three kinds of the Echinoid larvæ, two of which appear to belong to one and the same genus, the third to another genus of *Echini*.

One form, which I shall describe first, has an arched body, and may be compared to a spheroid or dome with four columnar, somewhat divergent, elongated supports or feet. These calcareous columns are continued into the spheroid, where they are further distributed in a peculiar manner, and which can only be rendered intelligible by figures. The columns are covered by the skin of the larva which forms the spheroid, and which forms arches at the margin of the arch between the columns. The spheroid has two broad and two narrow sides. The broad may be distinguished as the anterior and the posterior sides. Between the two anterior columns the skin of the larva forms a tent-like expansion at the margin of the spheroid; on the opposite posterior side the animal substance is continued from the dome into a long appendage, which is fixed by four separate columns, so that there are two on each side. This elongation contains the mouth and the œsophagus, the stomach is situated beneath the dome.

To assist comprehension by a comparison, the larva resembles a clock-case resting upon four long feet, from the back of which

* Bull. de l'Acad. Imp. de St. Pétersb. t. v. n. 15. p. 231.

the pendulum descends, which may be compared in our larvæ to the framework of the mouth. The columns of the oral framework also contain internally a calcareous column; two of these calcareous columns are branches of the two belonging to the four main columns, and pass off within the arched central body from those of the former which support the tent. The other two calcareous columns unite together at the back part of the dome at an angle, from which a single branch ramifies in the dome. The skin, which covers all the columns, the central body, and the expansion at the mouth, is spotted with sulphur-yellow and brown spots. The distribution of the ciliated organs is very peculiar. These larvæ are furnished with oblique tufts resembling epaulettes which are situated upon those spots where the four supports of the dome pass into it; the tufts are also covered with very long moving cilia; a thick mass of sulphur-yellow pigment lies beneath the tufts. Moreover these larvæ are furnished with a row of cilia upon all the columns and on the dome itself, as is the case with the *Pluteus*. Two rows run upon each column; these run into one another at the extremity and superiorly at the dome from one ray to the others. At the anterior margin of the dome, where the latter is expanded like a tent, the row of cilia follows the margin of this protection: not so at the sides; the arch of the row of cilia here lies much higher than the margin of the dome, and ascends almost as far as its summit. The columns also between which the mouth and œsophagus are situated are covered by a row of cilia, which passes from one ray to the other on the same side, and in the centre runs beneath the mouth from one side to the other. The mouth is surrounded by a distinct tuft of cilia. It is triangular, and bounded inferiorly by an oblique, basin-like projecting lip; the two other or upper sides are inclined to each other at an angle. In this direction the cavity of the mouth is continued into the œsophagus, which leads to the blind sac of the stomach. The latter receives the internal portion of the arched central body, and is frequently bent in several places, so that one portion of the blind sac is curved forwards. Both the mouth and the œsophagus contract powerfully from time to time. The interior of the cavity of the mouth, the œsophagus and the stomach is ciliated. These larvæ are about half a line long, and live unattached in the water, their motions being entirely effected by cilia. All the arms are immoveable; the columns which lie between the mouth and the œsophagus merely undergo a passive motion from the powerful contraction of the mouth and œsophagus.

The first appearance of alteration is recognised in these larvæ by a discoid plate, which is produced in the months of August and September on one of the narrow sides of the dome beneath

the spotted skin of the latter, and which is inclined at an acute angle towards the summit of the dome. In our comparison of the framework with a pendulum it forms as it were the dial-plate, but the position of the dial-plate would be heterologous to that of the pendulum, and it would be situated at the side of the clock-case. This disc is thus heterologous in position with the mouth of the larva. The round disc, which is now but slightly convex, becomes itself again spotted with yellowish spots. It is divided by a five-leaved figure into five valve-like divisions, which are almost in contact in the centre; at the circumference there are intermediate segments between them. Each valvular division has two outlines which are widely separated from each other. Opposite this disc, which forms the earliest appearance of the *Echinus*, there appear upon the dome on each side pedicellariæ, which are furnished with three arms such as are peculiar to the *Echini*; for the pedicellariæ of the *Asteriæ* have two arms. The pedicellariæ lie close to the dome; at this period they also exhibit spontaneous motion, the arms of the pincers opening and shutting. The larva has usually only four pedicellariæ, two on each side, situated near to each other.

During the growth of the disc within the dome, new segments appear at its marginal portions which inclose the five central plates: externally between the five plates there appear five circular figures with double outlines; these are the foundations for the tentacles or feet; for the young Echinoderm which is at this period in the progress of formation possesses the peculiarity, that at first it is furnished with only five regular, symmetrically distributed, large, odd feet, which rise from the apertures of the disc in the form of minute cæca with double outlines. The other peripheral segments, which cannot be confounded with the plates of the shell of the adult *Echinus*, soon shoot up into cylindrical elevations, which are converted into spines. When the young *Echinus* is so far developed as to form a slightly convex disc furnished with spines and five tentacles or soft feet, both the feet and the spines project far beyond the surface of the dome of the larva, the feet move in all directions in a groping manner, and are now in a condition to adhere to objects. The spines are also moveable at the will of the animal. The mouth of the larva still remains in its former position, and like the œsophagus is in full action. The feet are annulated, and like the spines, sparingly spotted with a yellow and brown pigment. Each of the five feet is furnished at its extremity with a disc, in the centre of which there is a tubercle, just as in the feet of the adult *Echinus* in their extended state, and as figured by Monro from life. Within the disc we find a polygonal simple calcareous rim. The minute feet are hollow internally, but at the extremity

the cavity is closed as in all the Echinodermata. At their first appearance the feet are rounded at the extremity; the disc is formed at a somewhat later period. The spines, which soon acquire a considerable length, contain a calcareous framework. When the latter is perfectly developed, it forms an hexagonal prism placed within the cylindrical skin of the spine, which consists of a regular calcareous lattice-work terminating at the extremity in minute teeth. The horizontal arrangement of the axial network of the spine is radiate, so that the extremity of the spine viewed from above exhibits a star with six segments. Before the framework of the spines is thus far developed, when it first appears it has exactly the form of a candelabrum. The basis of the framework of the spine is thus a star with six rays, from the centre of which there arises a simple axis, which immediately subdivides into other branches which subsequently re-unite. In this manner a tubercle is formed which gives off some teeth (*Zacken*) externally. The continued trunk again rises vertically from the tubercle, six long arms proceeding from it; these ascend parallel, and give off teeth externally. The length of the developed spines is so great, that it is about equal to the fourth part of the whole disc of the animal.

It is very enigmatical, that at first the tentacles or feet do not appear in pairs, since these five odd tentacles do not occur in any perfect *Echinus* or Echinoderm. I must leave it undecided, whether the spinous disc under consideration corresponds to the middle ventral portion with the framework of the teeth, as it appears to do, or whether it is the dorsal part of the subsequent *Echinus*. If it were the dorsal portion, the five-cleft figure would exhibit the five genital plates in the centre, and the segments from which the tentacles arose, between the above plates, would correspond to the perforated plates, which M. Agassiz, without sufficient ground, denominates the ocellar plates; the centre between the five original valves would then be considered as the anus. At this period there is no aperture at this point, and the spotted skin of the larva is continued over it. Moreover the shell of the *Echinus* is at this time a delicate structure, the segments of which growing into tentacles and spines cannot be considered as the subsequent plates of the shell, but as the foundations of the tentacles and spines. Moreover the foundations of the subsequent arrangement of the tentacles in pairs may now be recognised, for just anterior to those tentacles which are not in pairs, near the centre, there are two smaller, circular rudiments of the tentacles, lying in pairs; thus a circle of ten tentacles is produced; and more towards the circumference, rudiments of tentacula arranged in pairs are visible. The disc itself, from which the tentacles and spines arise, also contains its peculiar calcareous network, which is not

visible until we examine more minutely. It is first formed from isolated figures with three arms, which are bifurcated and soon form a lattice-work with circular meshes. At this stage of the metamorphosis the larva swims about by its ciliary organs, which remain in full activity, viz. the ciliary lines and the ciliary epaulettes, it creeps with its five feet, moves its pedicellariæ like pincers, and each spine separately. I have not had an opportunity of tracing the metamorphosis of these larvæ: the convex discoid form of the new animal, its total dissimilarity from the *Asteriæ* and *Ophiuræ*, the numerous spontaneously moveable long spines on the disc, and the three-limbed pedicellariæ, leave scarcely any doubt that it represents one of the *Echinidæ*, but it is impossible to say from these data whether it belongs to the genus *Echinus* or *Cidaris*.

To the same genus as that above described, in numerous specimens and in larvæ seen several times almost every day, there belongs also the larva of another species which resembles the former in every respect, and especially in the ciliated epaulettes, but which appeared to differ in the termination of the calcareous axis in the dome; for instead of the round dome, the summit was conical and then truncated at the extremity. The calcareous axes of the two anterior main arms of the larva projected into this extremity and subdivided in the apex into two short oblique branches. The position of the disc in the dome and its structure were the same as in the other species.

My observations on the larvæ of the Echinodermata with ciliated epaulettes have proceeded thus far. To observe the complete development of the *Echinidæ*, it would be necessary to continue the investigations through the first half of the winter. From observations on another species of larva which will be detailed hereafter, it is evident that the young *Echinus* has entirely lost all traces of the larva even when the spinous part of its surface is developed as far as a half of its entire sphere, and that the remaining part of the shell is subsequently perfected. As the sea had become agitated and unfavourable to these investigations, it must at present remain undecided whether the spinous surface corresponds to the dorsal or ventral part of the *Echinus*, and whether the five-limbed figure in the centre of this part belongs to the genital plates with the anus, or, on the contrary, to the dental framework and mouth.

A third species of larva belongs to another genus of spinous Echinodermata, probably also one of the *Echinidæ*. I have not met with this species very frequently, but have traced it furthest in its metamorphosis and up to that point at which the new spinous spherical Echinoderm has lost all traces of the larva.

These larvæ, somewhat larger than the larvæ of the *Ophiuræ*, are

remarkable in possessing, in addition to the four arms which emanate from the margin of the dome, and the other four arms which form the framework of the mouth and œsophagus, two other arms which run backwards and downwards, and also three distinct ones running from the external surface of the dome, thus in all thirteen arms; moreover in the four ciliated plates which exist in the former genus being here entirely absent, and in the arms (excepting the two supernumerary ones behind and below) being extremely long. Of the three peculiar arms on the dome, the odd one forms a more or less elongated, frequently very long stalk on the summit of the dome, as if it were the elongated axis of the animal. It contains a calcareous skeleton, *i. e.* a reticulated axis with three longitudinal ridges. Opposite that foot, upon which this axis rests upon the dome, it subdivides into two calcareous ridges, which descend within the dome and are continued into its lateral arms. The three axes at the dome are not covered with cilia; the ciliated plates are also entirely absent. The cilia covering the lower arms and the arches between them are arranged as in the previous genus. The four extremely elongated main supports of the dome contain reticulated calcareous axes; the calcareous axes of the four equal elongated appendages which form the oral framework and the supernumerary posterior and inferior appendages are simple. The dome is much higher in this species. The distribution of the calcareous ridges from the axes within the dome is exactly similar to that in the previous genus, especially that species in which the dome is round. Some of these larvæ did not exhibit any trace of the disc of the *Echinus*, others had it on the single lesser side of the dome; in others the disc was covered with spines, and between them ambulacral pores and tentacles existed. I have never seen pedicellariæ in this species. The spines exactly resemble those of the previous genus, and become so elevated, that they project beyond the larva and the animal moves them spontaneously. The calcareous skeleton existing in them forms a six-sided prism of lattice-work, the upper ridges of which are elongated beneath the external tegument of the spine into small teeth. The internal arrangement of the axes in the substance of the spine is also six-rayed. The whole surface of the disc is densely covered with these spines, and like the entire larva and its appendages, they are spotted with yellow and brown pigment. Its size is as considerable as that of the previous genus; the length is equal to the third or fourth part of the diameter of the whole body upon which they are situated. It is worthy of remark, that the disc with the spines is longish oval, round, and is considerably more elongated inferiorly than in the previous genus. The disc upon which the spines are situated consists of a calcareous net of lattice-work.

One of these larvæ was once seen in which the axis of the larva had almost entirely disappeared, and in which no further trace of the oral framework remained. The young *Echinus* formed an elongated, spherical, somewhat flattened body without a trace of any Echinoid arms, and in which one half of the surface was completely covered with spines, but the other half was still cutaneous and exhibited traces of the integument of the dome of the larva. For in addition to the pigment spots, several irregular remains of the innermost concealed part of the column and its branches in the dome were visible. The spinous side was convex like a watch-glass, but elongated, and here and there exhibited ambulacral pores, and at the circumference some very large tentacles or feet projected, the distribution of which I could not clearly ascertain. No mouth is visible at the opposite cutaneous portion of the flattened sphere. This may possibly exist at one extremity of the elongated body, but it was impossible to determine this from the opaque structure of the body. The length and form of the spines are the same as in the above.

On one occasion an exactly similar body, of equal size, spinous upon one half, elongated, spherical and somewhat flattened (one-fifth of a line long), and free from all larval remains, was observed. Like the previous one it was obtained near the surface of the sea, but it moved upon the glass exactly like an *Echinus*, putting the spines separately into action, and at the circumference extending some large tentacles, by which it held on to the glass. The centre of the spinous surface was free from spines. I recognised a surface divided into five parts and with a pentagonal centre, through the skin spotted with pigment which exists at this part. The side opposed to the spinous half was convex, but still covered merely by the spotted integument, beneath which, remains of the calcareous axes of the larva were still visible. Neither on this occasion was any certain information obtained regarding the mouth, and it remains doubtful whether it existed at either extremity of the elongated, round body. The question is, whether the entire series of developmental phenomena just described belongs to an *Echinus* or rather *Spatangus*. Although the ultimate forms of the larvæ which have been examined are so different, nevertheless it is remarkable that the larvæ of the *Ophiuræ* and *Echini* agree in being formed upon a certain common plan. The larvæ of the *Asteriæ* observed by Sars differ most, but these also agree with the common plan in their bilateral appendages; hence it may be supposed that an analogous starting-point may be found for all the Echinodermata. For this purpose, however, it will be necessary to re-examine the larvæ of the *Asteriæ*. Their internal structure and the position of their mouth are entirely unknown; moreover I have not succeeded in observing from the

larva of *Echinaster Sarsii*, which is preserved in the museum of M. Christie in Bergen, anything more than what has been described and figured by M. Sars.

At the time when these larvæ have developed the star-fish of the *Asterias*, the arms of the larvæ still being present, their greatest diameter is two-thirds of a line. Two pairs of tentacles are developed in each of the five rows of tentacles. But no trace of aperture can be recognised in the centre of the ventral side of the star-fish. If the oral aperture of the larva, as I suppose, exists between the four arms of the larva, the mouth of the *Asterias* is formed independently of the supposed mouth of the larva. The most central and lowest tubercle, situated between the four other bulbous warts, has a slightly rounded and somewhat basin-shaped aspect. Although these larvæ are absolutely larger than the larvæ of the *Ophiuræ* and *Echini*, nevertheless they appear to contain little or no skeleton within them. From their perfect opacity and uniform red colour, I endeavoured to render their skeleton visible by dissolving the animal parts in caustic potash, but this proceeding did not bring into view any portions of a skeleton.

The supposition of Sars, that the warty appendages of the larva of the *Asterias*, by means of which it adheres to the marsupial cavity of the mother, are subsequently transformed into the madre-pore-plates, does not appear to me probable. These appendages are evidently the same as the four symmetrical supports of the body of the larva of the *Echini* and the appendages of *Pluteus*; in both they disappear entirely, without being transformed into any other organ, and the young *Echinus* loses them before the madre-pore-plates can be distinguished. Moreover the Echinoid larvæ which I last described possess so many arms on their body and on so many spots which are partly opposite, that a conversion of them into the subsequent madre-pore-plates is impossible, on account of the situation which these arms occupy on the anterior, posterior and lateral part of the larva.

XI.VI.—Notes on the genus of *Insects* *Otiorhynchus*, with descriptions of new species. By JOHN WALTON, F.L.S.

[With a Plate.]

Fam. CURCULIONIDÆ.

Genus OTIORHYNCHUS, *Germ.*, *Schönh.*, *Steph.*, *Curt.*

§ A. *Femora dentate*.

1. *Otiorhynchus Ligustici*, *Linn.*, *Mus. Linn.*, *Marsh.*, *Gyll.*, *Steph.*, *Schönh.*

Rare, or very local; Mr. Smith found three specimens on Hawley-flat, near Blackwater, Hampshire, in June. Frequently